69955
SPEEDOMAX® G X_1-X_2 RECORDER

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CONTENTS

Section		Page
	PART I	
	GENERAL INFORMATION	
1.	Introduction	5
2.	Description	5
	PART II	
	PREPARATION FOR SERVICE	
3.	Unpacking and Mounting	7
4.	Wiring Connections	7
5.	Installation of Dry Cells	7
6.	Installation of Chart	7
7.	Preparation of Pens	8
8.	Initial Lubrication	9
9.	Amplifiers	9
10.	Initial Adjustments	9
	A. Sensitivity Adjustment	9
	B. Damping Adjustment	10
	C. Adjustment of Disk Operated Control Switch Assemblies	11
	PART III	
	MAINTENANCE AND SERVICING	
11.	Calibration	13
	A. Potentiometer Circuit	13
	B. Wheatstone Bridge Circuit	16
12.	Maintenance	16
	A. Cleaning and Lubricating	16
	B. Motor Bearings	16
	C. Pens	18
	D. Replacement of Dry Cells	21
	E. Amplifier	21
13.	Miscellaneous Servicing	21
	A. Installation of Pen Carriage Drive Cords	21
	B. Replacement of Slidewires	22
	C. Installation of Slidewire Contacts	23

CONTENTS

Section — Page

PART IV
TECHNICAL INFORMATION

14. Summary 25
15. Measuring Circuits 26
    A. Potentiometer Circuit 26
    B. Wheatstone Bridge Circuit 27
16. Filtering 27
    A. Input Filter 28
    B. Input Circuit Capacitor 28
17. Damping 28
18. Conversion of Error Signal 29
    A. Converter 29
    B. Input Transformer 30
19. Voltage Amplification 30
20. Balancing Motor Operation 30
21. Regulated Voltage Power Supply Unit 31

APPENDIX I

Recommended Spare Parts 33

APPENDIX II

Potentiometer Measuring Circuit Equipped with Manual Standardizing Components 35

69955

SPEEDOMAX G X_1-X_2 RECORDER

PART I

GENERAL INFORMATION

1. INTRODUCTION

The 69955 Speedomax G X_1-X_2 Recorder simultaneously indicates and records on the same chart two separate variables (such as temperature, emf, resistance, etc.) as functions of time. Thus, the recorder can present for instantaneous comparison on one chart such measurements as: temperature and temperature difference; temperature and elongation; stress and strain; temperature and pH; temperature and pressure; width and thickness; etc. Fig. 1 illustrates a typical 69955 X_1-X_2 Recorder*.

2. DESCRIPTION

As shown in Figs. 2 and 3, the measuring slidewire and balancing motor for each function are located on the main frame casting. One amplifier is mounted inside the recorder case and the other is mounted on the rear of the case where it is protected by an enclosure. The two pens are usually arranged to overlap in operation, each pen traveling the full width of the scale. With this arrangement the X_1 pen is advanced vertically about 1/8 inch ahead of the X_2 pen. The two pens can also be aligned horizontally. In such an arrangement, the travel of each pen is restricted by suitable stops to a specified portion of the chart: for example 1/2 and 1/2, 2/3 and 1/3, etc. The approximate "dead" space between the two portions of the chart is 1/2 inch. Inks of different color may be used to identify the two functions.

The following table is provided so that the various components associated with each function may be readily identified.

COMPONENT	X_1-FUNCTION	X_2-FUNCTION
Mechanism and Slidewire	Hinge side of main frame	Latch side of main frame
Scale and Pointer	Lower	Upper
Pointer Color	Black	Red
Pen	Leading on time axis	Lagging on time axis
Amplifier	Inside recorder case	Outside recorder case

* The recorder shown differs from a standard 69955 X_1-X_2 Recorder in that, as an optional feature, each of the recorder's two functions (X_1 and X_2) are furnished with two separate scale ranges. To select the desired range for each function, this recorder is provided with two range switches. These toggle switches are mounted on a panel attached to the left side of the recorder's upper structure as shown in Fig. 1.

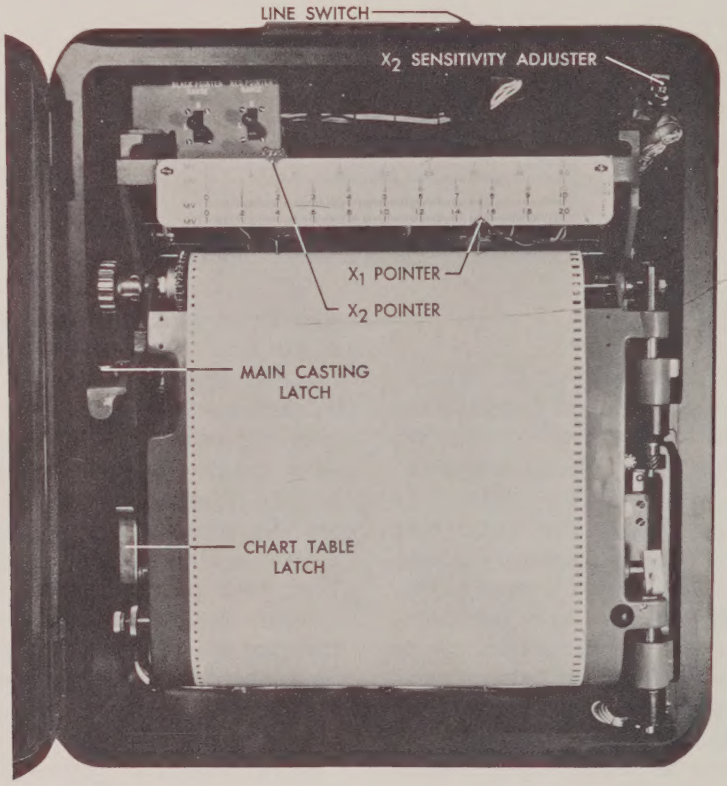


Fig. 1—69955 Speedomax G X_1 - X_2 Recorder.

The actual measuring circuits used in a particular 69955 Speedomax G X_1-X_2 Recorder are shown on the separate wiring diagram furnished with the recorder. They vary according to the kind of measurements for which the recorder was intended. In almost all instances, however, the circuits will be variations of either a potentiometer circuit (for temperature, emf, etc. measurements) or a Wheatstone bridge circuit (for resistance, etc. measurements). The above two types of measuring circuits are described in Section 15.

NOTE: The potentiometer measuring circuits* in standard 69955 X_1-X_2 Recorders are equipped with regulated voltage power supply units. Such units are not normally used in Wheatstone bridge measuring circuits, as d-c bridge circuits use dry cells and a-c bridge circuits use a-c power obtained from the power transformer in the circuit's amplifier. However, any d-c bridge circuit can be equipped with a regulated voltage power supply unit, if the unit is ordered as an optional feature.

* Any potentiometer measuring circuit can be equipped with a dry cell and manual standardization components in place of the regulated voltage power supply unit, if such components are ordered as an optional feature. Refer to Appendix II for information and instructions that are pertinent to such a measuring circuit but that are not included in the main text of this instruction book.

PART II

PREPARATION FOR SERVICE

3. UNPACKING AND MOUNTING

Carefully unpack the recorder, follow the instructions on any tags or labels, and remove any shipping clamps. Unless otherwise specified, the recorder is arranged for flush mounting on a panel by means of studs which are packed with the accessories. A drawing showing the outline and drilling dimensions is furnished separately.

Ground the recorder case unless specific exception is made on the recorder's wiring diagram. The use of lockwashers with the mounting studs will effect such grounding when the recorder is mounted on a metal panel. When an insulated panel is used, make connections from one of the mounting studs to a ground bus.

4. WIRING CONNECTIONS

Detailed wiring connections are shown on the one or more diagrams supplied with the equipment. Make all connections in accordance with such diagrams. Connect the grounded side of the power supply to the terminal marked MG.

Connect the primary elements (that is, the sources being measured) to the terminals as shown on the diagrams. Observe any instructions supplied with the primary elements. Although special precautions are not usually required, it may be necessary in some installations to shield the primary element leads or to route them so as to avoid strong fields produced by electrical equipment.

Where the recorder is used for measurement on high voltage equipment, ground one side of the primary elements at the high voltage equipment, if the measuring circuit arrangement permits such grounding. This will protect both the personnel and the recorder in the event of high voltage breakdown to the primary elements.

5. INSTALLATION OF DRY CELLS

When dry cells are used in the recorder's two measuring circuits, they are supplied unmounted. Mount the cells in the holders provided for them inside the recorder case. Connect the leads to the cells in such a manner that the polarities marked on the leads match those of the cell terminals.

6. INSTALLATION OF CHART

Release the chart table latch, Fig. 1, and swing out the table to install the chart as shown in Fig. 4.

The reroll spindle is the red fiber tube (or wood roller), slotted at each end, which is packed with the accessories.

The right end of the chart roll (as viewed in Fig. 4) should be so adjusted that there is about 1/32" clearance between the end of the chart roll at A and the inside face of the flange. Loosen knurled nut N, Fig. 3, and turn nut M, Fig. 3, to make this adjustment.

Turn knob K, Fig. 4, to feed some paper from the supply roll to the reroll spindle. Make sure that the pins at both ends of the drive roll fit through the holes in the edges of the paper,

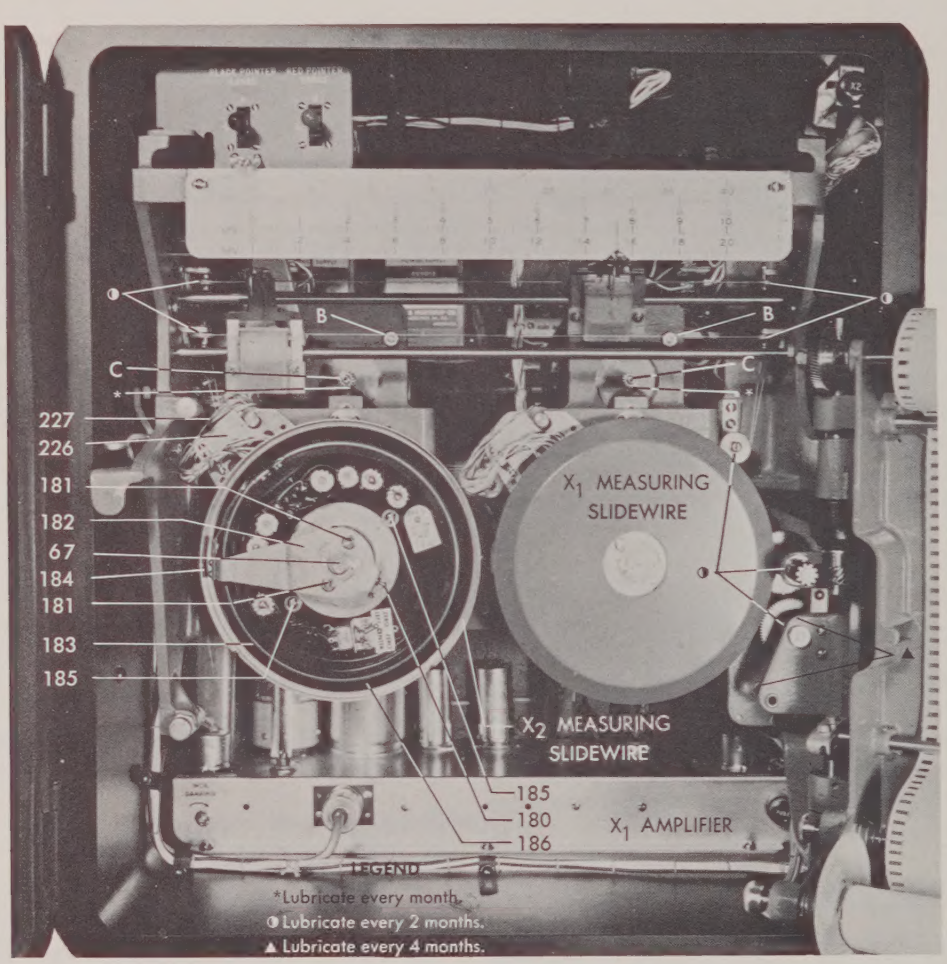


Fig. 2—Chart assembly swung to side and X_2 slidewire cover removed.

that the horizontal lines on the paper are parallel to the axis of the drive roll, and that the paper lies flat against the front of the chart table.

7. PREPARATION OF PENS

Fig. 5 shows the two pens mounted in place. Note that the pens shown in this figure are adjusted for full scale travel as described in Section 2. (Pens whose travel is restricted to a specified portion of the chart must have their points aligned horizontally.)

Since the two pen assemblies are usually shipped unmounted, mount them on their brackets as shown in Fig. 5.

The pen having the smaller radius and longer plastic tube is the X_2-function pen. To mount this pen, hold it with the point facing down and with the tube under the bracket and support as shown. Make sure that one spring fits on top of the support and the other fits under the support (in the groove) as shown in Sketch C. Then fit the pivot points of the pen block into the bearings of the support.

Mount the other pen (larger radius and shorter tube) in its bracket. This pen fits into its support in the same manner as described above for the X_2-function pen. However, in this instance, the tube fits up over the support and then down through the holes in the bracket as shown.

With each pen reservoir in place on its carriage, use the plastic ink bottle, which is supplied with the accessories, to fill the two reservoirs. Insert the end of the tube attached to the bottle through the top hole in the reservoir and then squeeze the bottle. To prevent possible spillage, the ink level should be about 1/4 inch from the top of the reservoir.

Each pen must be primed after the reservoirs have been filled. That is, the pen capillary must be filled to start the ink flow. The pen must be reprimed only when the capillary is emptied during cleaning, or if it is allowed to become completely dry. The reservoirs should always be refilled before they become empty.

To avoid the possibility of deforming the pen assembly while priming each pen, remove the pen assembly from the pen bracket, but allow the plastic tube to remain in the reservoir. Squeeze the plastic ink bottle to remove excess air, and then tightly fit the end of the tube attached to the bottle over the pen point. Now release pressure on the bottle, thus drawing ink from the reservoir into the pen capillary. If necessary, repeat this procedure until some ink has been drawn all the way through the pen capillary. When remounting the pen assembly, make sure that the springs are fitted on the support as shown in Sketch C, Fig. 5, and that the pen point registers on the proper line on the chart with the large split gear behind the measuring slidewire held against the low-end stop.

If a pen fails to draw a line on the chart, moisten a finger and draw it across the pen point. If this procedure fails to start the ink flowing, clean the pen as directed in Section 12C.

8. INITIAL LUBRICATION

The recorder has been properly cleaned and lubricated before leaving the factory. There are certain points, however, which should be relubricated before the recorder is placed in service. These points are indicated on Figs. 2 and 4 by ◑. Apply one or two drops of oil at each point and then remove any excess oil.

9. AMPLIFIERS

The X_1 amplifier is mounted inside the recorder case, while the X_2 amplifier is mounted outside the case as shown in Fig. 6. A protective cover, which is not shown in Fig. 6, is mounted by screws which fit through slotted holes in the cover. This permits easy removal and replacement of this cover.

Make sure the converter, tubes, and plugs of both amplifiers are properly seated in their sockets.

10. INITIAL ADJUSTMENTS

10A. Sensitivity Adjustment

The amplifier sensitivity for each function has been adjusted at the factory and normally will not require initial readjustment. However, the sensitivity of both the X_1 and X_2 amplifiers should be checked before placing the recorder in service and the sensitivity settings corrected, if necessary.

The location of the sensitivity

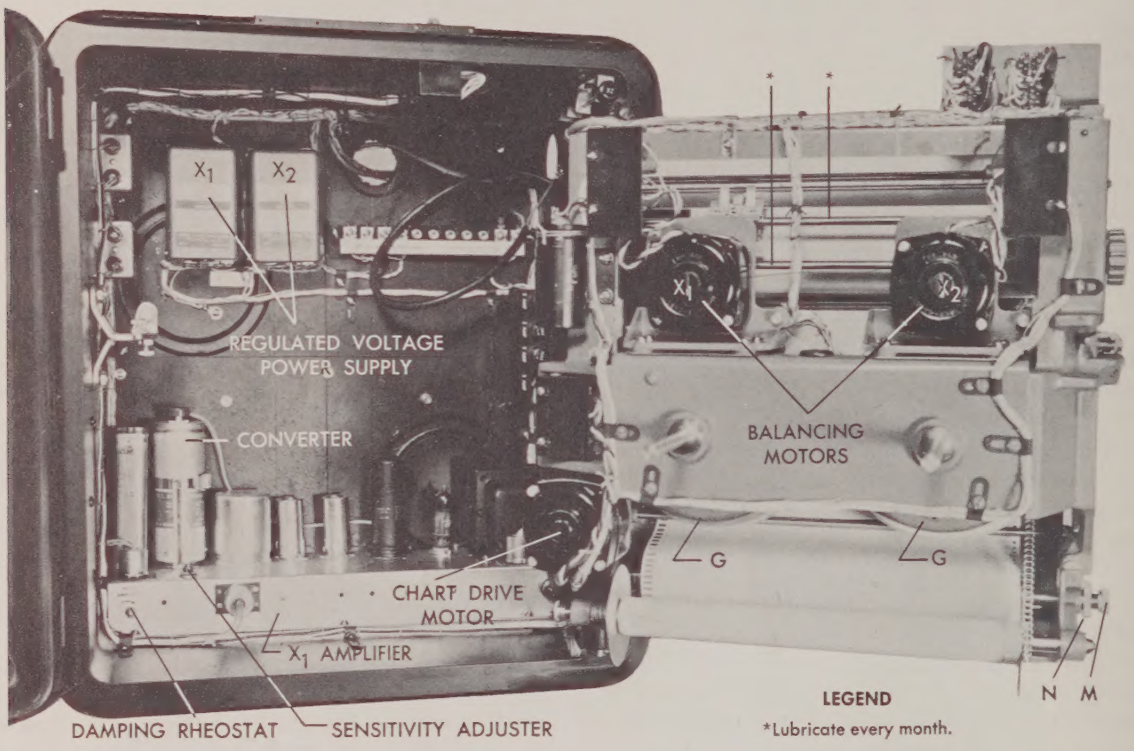


Fig. 3—Interior view of recorder.

adjuster for the X_1 amplifier is shown in Fig. 3. As shown in Fig. 1, the sensitivity adjuster for the X_2 is located at the upper right corner of the case. This knob is coupled to the regular amplifier adjuster through a flexible shaft. For certain special recorders, a similar arrangement is provided for the X_1 amplifier; the controlling knob in this event is located at the upper left corner of the case.

The proper setting for each amplifier is that setting which provides maximum sensitivity without "hunting" (that is, pen or pointer oscillation). If oversensitivity (characterized by hunting) or insensitivity (characterized by sluggish response or by an objectionable width of dead band when coming into balance from opposite ends of the scale) is noted, turn the sensitivity adjuster to its clockwise limit. Then turn it slowly counterclockwise until the hunting ceases.

10B. Damping Adjustment

A damping rheostat is provided on each amplifier. This rheostat is mounted on the amplifier chassis and is identified by the legend "INCREASE DAMPING". After adjusting the sensitivity rheostats as indicated in Section 10A, adjust the damping rheostats for proper damping of the balancing motors. Underdamping is characterized by overshoot of the balance point; overdamping by too slow an approach to the balance point and by an approach in numerous small steps.

10C. Adjustment of Disk Operated Control Switch Assemblies

Each recorder function may be equipped with a disk operated control switch assembly mounted on the function's measuring slidewire shaft. Before placing the recorder in operation, check the settings of the disks in such assemblies to determine whether their respective switches are operating as required.

To make such checks, proceed as follows:

Rotate the proper split gear G, Fig. 3 until the corresponding scale pointer is positioned at the scale reading at which the switch whose operation is being checked is to operate.

Then connect an ohmmeter to the appropriate recorder terminals to determine whether the switching action has occurred. If it hasn't, adjust the appropriate disk until the switching action does occur.

To do this, first loosen the nut at the front of the control switch assembly. Then rotate the disk until the switch operates. Finally, tighten the loosened nut to hold the adjustment. When making this adjustment, make sure that the positions of the other disks in the assembly are not disturbed.

PART III

MAINTENANCE AND SERVICING

11. CALIBRATION

This section outlines the procedures for checking the calibration accuracy of the recorder. Such an accuracy check will be required when measuring circuit components are disturbed—that is, after removal and replacement of the measuring slidewire, installation of new slidewire contacts, removal and replacement of the regulated voltage power supply, etc. The user may also wish to check the calibration periodically.

11A. Potentiometer Circuit

The general method for checking the calibration is to compare the recorder reading against a known emf. However, before making any electrical checks, check the pen carriage alignment as directed in Section 12C. Also check and, if necessary, adjust the alignment of the recorder scale with the pen carriage pointer.

If the recorder is used for straight millivolt measurements and automatic reference junction compensation is not employed, proceed as follows:

(1) Energize the recorder and then allow it to warm up for at least thirty minutes.

(2) Connect the EMF terminals of a portable reference potentiometer, such as an L&N® 8686 or 8690 Potentiometer, to the recorder's EMF terminals, after disconnecting any other external source of emf.

(3) Set the millivolt output of the reference potentiometer to a value which will drive the pen to the low end of the recorder scale. Then increase the applied emf to a value that will drive the pen to almost the high end of the scale. Note the reading of both the recorder and potentiometer. These two readings should correspond within the recorder's limits of error (0.3% of full scale range). If they do not, turn the adjusting screw on the appropriate regulated voltage power supply until the readings correspond.

To gain access to the power supply unit's adjusting screw, it will be necessary to remove the chrome plug button from the terminal side of the unit. The locations of the power supply units are shown in Fig. 3.

Now check several other points within the recorder scale range. Make the pointer approach such points from both the low end and high end of the scale. If there is an appreciable difference between the two readings, adjust the amplifier's sensitivity adjuster to decrease the width of the insensitive band.

If the reference potentiometer and recorder readings fail to correspond in spite of any setting of the power supply's adjusting screw, check the power supply with a voltmeter. To do this, first unsolder the leads attached to the + and – terminals of the power supply. Then connect a resistor having a value between 101 and 109 ohms to these terminals. With the power supply energized, a voltmeter connected across the + and – terminals should read between 1.01 and 1.09 volts. The setting of the power supply's adjusting screw may have to be changed to get a voltage output within the above range.

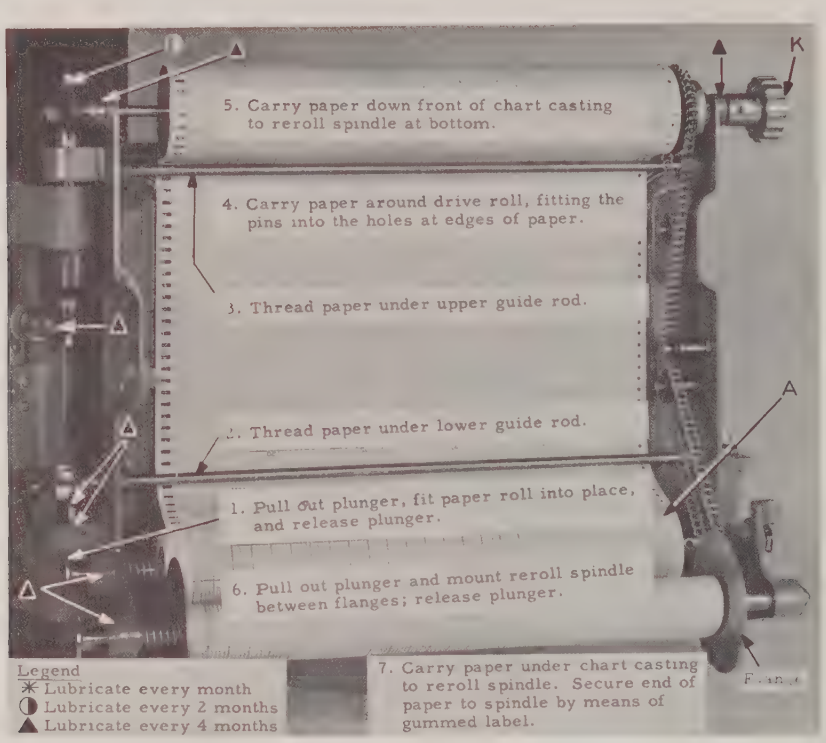

5. Carry paper down front of chart casting to reroll spindle at bottom.
4. Carry paper around drive roll, fitting the pins into the holes at edges of paper.
3. Thread paper under upper guide rod.
2. Thread paper under lower guide rod.
1. Pull out plunger, fit paper roll into place, and release plunger.
6. Pull out plunger and mount reroll spindle between flanges; release plunger.
7. Carry paper under chart casting to reroll spindle. Secure end of paper to spindle by means of gummed label.
K
A
Legend
✳ Lubricate every month
◑ Lubricate every 2 months
▲ Lubricate every 4 months

Fig. 4—Chart installation instructions.

Such an output indicates that the power supply is operating properly and that the fault lies elsewhere in the recorder.

If the recorder is used for temperature measurements and employs automatic reference junction compensation, proceed as follows:

(1) Energize the recorder and then allow it to warm up for at least thirty minutes.

(2) Determine the millivoltage equivalent to some major division near the center of the recorder scale. Also determine the millivoltage equivalent to the reference junction temperature. Do this by measuring the temperature with a suitable thermometer and by referring to the temperature conversion table, based on either 0 F or 0 C, for the type of thermocouple being used. The difference between the two values is the "effective" millivoltage.

(3) Connect the EMF terminals of the portable reference potentiometer to the proper pins on the reference junction compensator, as indicated in Fig. 7. This compensator is mounted on a bakelite bracket which is mounted inside the hollow in the bottom of the main frame casting between the two measuring slidewire shafts.

(4) Set the reference potentiometer millivoltage output to the value of the "effective" millivoltage which was just computed. The scale pointer should come to rest at the major division which was previously selected,

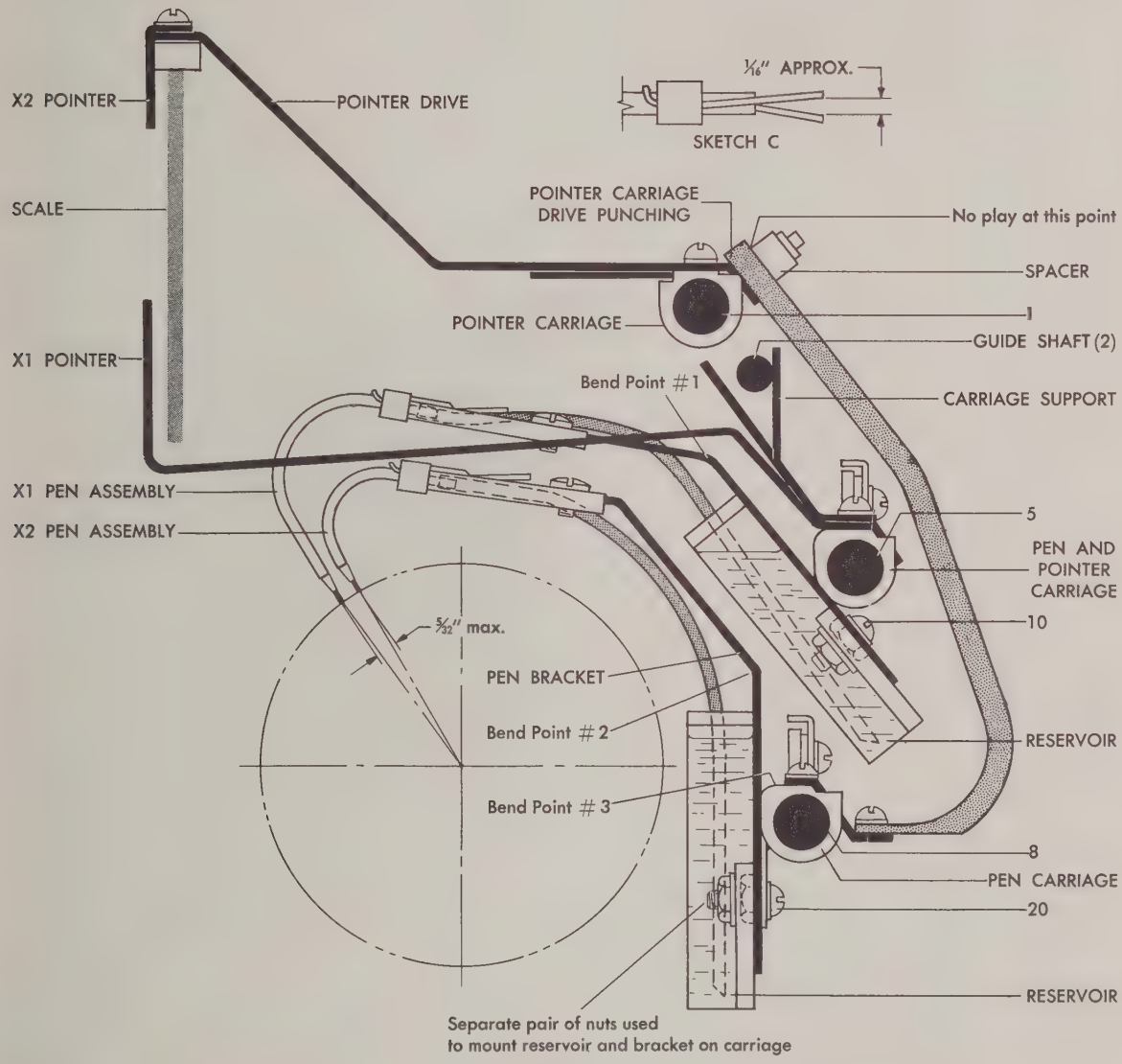


Fig. 5—Pen adjustments.

within the recorder's limits of error (0.3% of full scale range). Eliminate any deviation of the recorder pointer from its correct setting by turning the adjusting screw on the regulated voltage power supply.

Now check several other points within the recorder scale range. Make the pointer approach such points from both the low end and high end of the scale. If there is an appreciable difference between the two readings, adjust the amplifier's sensitivity adjuster to decrease the width of the insensitive band.

If the reference potentiometer and recorder readings fail to correspond in spite of any setting of the power supply's adjusting screw, check the power supply with a voltmeter. Do this as directed in Step 3 of the instructions for the millivolt recorder.

11B. Wheatstone Bridge Circuit

A checking resistor is supplied with all recorders having Wheatstone bridge measuring circuits. This precision resistor permits a rapid calibration at one point of the recorder scale. To make this check, disconnect the primary element at the recorder's terminal board and connect the checking resistor in its place. The recorder reading should correspond to that specified on the checking resistor within ±0.3% of full scale range.

If the recorder does not check at the specified value, adjust the measuring slidewire as follows:

(1) Remove the cover from the slidewire and loosen screws 185, Fig. 2 a slight amount.

(2) Adjust the slidewire disk until the recorder reading is correct.

(3) Tighten the two screws in the disk and replace the cover.

12. MAINTENANCE

12A. Cleaning and Lubricating

(1) General Instructions

Since the recorder is usually a continuously operating mechanism, it must be cleaned and lubricated periodically. Refer to the lubrication instructions specified in Figs. 2, 3, 4, and 8. Use a good grade of medium weight oil for the lubrication. Also lubricate the drive cord pulleys, Fig. 9, every two months. In order to oil the reduction gear section of the chart motor drive on some recorders, it may be necessary to remove the screw and washer to which the arrow points in Fig. 8. After oiling this gear section, it is not necessary to replace the screw.

(2) Pen Carriage Shafts

Clean and lubricate the pen carriage and X_2 pointer shafts every two months by placing a small quantity of oil on a cloth and rubbing the shafts until they are clean. Leave a film of clean oil on the shafts for lubrication purposes.

(3) Slidewires

Clean the measuring circuit slidewires about every two months. Rub a cloth moistened with benzine over the contacting surface of each slidewire. If the recorder is in a location where the use of benzine is prohibited, use carbon tetrachloride instead—but use it sparingly. Do not apply any lubricant to these slidewires.

12B. Motor Bearings

(1) General Information

The chart and balancing motors are equipped with end-sealed type ball bearings properly packed with grease before leaving the factory. They should, therefore, require no attention for at least a year, or possibly two years. It is recommended that no lubricant be added to the bearings and that the bearings be replaced with new ones when they become objectionably noisy.

(2) Installation of Chart Drive Motor Bearings

Refer to Fig. 3.

Disconnect the motor leads from the terminal block. Then remove the three mounting screws and the nut and washer from the fourth screw and lift the motor from the casting. In some instances it will be necessary to remove the gear from the motor shaft before the motor can be removed from the casting. Otherwise, remove this gear after the motor has been removed from the casting.

Remove the four screws which hold the top end cover in place. Then tap the top end cover to loosen it and remove the cover from the motor. In doing this, be careful to note the arrangement of any thrust plate and washers on this end of the motor shaft. Lift the motor rotor out of the motor frame, being careful to note the arrangement of any washers on this end of the motor shaft.

Use a bearing puller, or other convenient method, to remove the bearings from the shaft. Place the new bearings (L&N Part No. 008052, packed with grease) on the shaft. Be sure to push the new bearings tightly against the shoulders on the shaft. In doing this, be sure to place pressure only on the inner ball race which is lower than the outer race.

Replace any spacers on the lower end of the shaft and insert the rotor in the stator. Then replace the washers, etc., on the upper end of the shaft and replace the top end cover. Adjust the top end cover and replace the through bolt with the nut to hold the cover in place. Replace the gear on the motor shaft and fasten it with the pin.

Replace the motor on the casting, align the spur gears, and see that they do not bind. Then replace and tighten the three screws in the casting to hold the motor in place. Mount and tighten the nut on the fourth through bolt and then connect the motor leads to the terminal block.

(3) Installation of Balancing Motor Bearings

Refer to Fig. 3.

Disconnect the motor leads from the terminal block. Then remove the nuts from the ends of the four mounting bolts (one is shown at B, Fig. 2) and remove the motor from the recorder. Remove the gear from the end of the motor shaft.

Remove the four screws or through bolts which hold the top end cover in place. Then tap the top end cover to loosen it and remove the cover from the motor. In doing this, be careful to note the arrangement of any thrust plate and washers on this end of the motor shaft. Lift the motor rotor out of the motor frame, being careful to note the arrangement of any washers on this end of the motor shaft.

Use a bearing puller, or other convenient method, to remove the bearings from the shaft. Place the new bearings (L&N Part No. 008052, packed with grease) on the shaft. Be sure to push the new bearings tightly against the shoulders on the shaft. In doing this, be sure to place pressure only on the inner ball race which is lower than the outer race.

Replace any spacers on the lower end of the shaft and insert the rotor in the stator. Then replace the washers, etc., on the upper end of the shaft and replace the top end cover. Adjust the top end cover and replace the four screws or through bolts to hold the cover in place.

Replace the gear on the motor shaft and tighten the nut. Fit the motor

approximately in position in the recorder but do not mesh the gear on the motor shaft with the gears at C, Fig. 2. First, displace the two sections of the large split gear a distance of three teeth to place tension on the springs on this gear. Hold the two sections of gear G, Fig. 3, displaced as above and mesh the gear on the end of the motor shaft with the gears at C, Fig. 2. Be sure these gears do not bind. Then tighten the four mounting bolts to hold the motor in place. Reconnect the motor leads to the terminal block.

12C. Pens

(1) Refilling and Cleaning

It is recommended that the pens be refilled before their reservoirs become empty.

If either pen should stop inking while it still contains ink, moisten a finger and draw it across the pen point. If this procedure fails to start the ink flowing, insert a cleaning wire in the pen point and push it through to remove any material clogging the pen.

If the ink still does not flow, remove the pen assembly and the attached plastic tube from the pen bracket. Place the clogged pen in alcohol or hot (not boiling) water for a short time. (Boiling water will soften the plastic tubing.) Remove the pen and insert a cleaning wire in the pen point. Blow any remaining liquid out of the pen. Then allow the pen to dry thoroughly before using it. When remounting the pen assembly, make sure that the springs are fitted on the support as shown in Sketch C, Fig. 5. Also make sure that the pen point registers on the proper line on the chart, with the large split gear behind the measuring slidewire held against the low-end stop.

To clean either reservoir, remove the two nuts which hold it in place and then run hot (not boiling) water into it. A piece of a paper towel may be folded and used to clean the inside surfaces of the reservoir.

(2) Adjustments

Pens which travel the full scale width for each recorded function have been so adjusted that their points are far enough apart to permit the pens to pass each other. The maximum permissible displacement is 5/32". Pens which travel only a specified portion of the scale have been adjusted so that their points are in alignment horizontally.

When the chart assembly is raised (by latching it in position), both pens should contact the paper just as the assembly reaches its raised position and should draw short lines on the paper not exceeding 1/16" to 3/32". To prevent possible damage, pens for full scale travel have been adjusted to pass each other when the chart assembly is lowered (that is, unlatched).

Since the pens have been properly adjusted prior to shipment, no additional adjustments are required. However, the adjustment procedure used at the factory is provided below. Remove the two reservoirs before making any adjustments.

(a) Refer to Fig. 10 which is a drawing of the lower hinge on the main frame assembly. Lower the chart assembly, but do not swing it out. Loosen the setscrew and adjust the stud so that there is a space of 1/16" to 3/32" between the bottom of the stud head and the hinge pin. Tighten the setscrew to hold this adjustment.

(b) With the chart assembly lowered, bend the two rear tabs on the

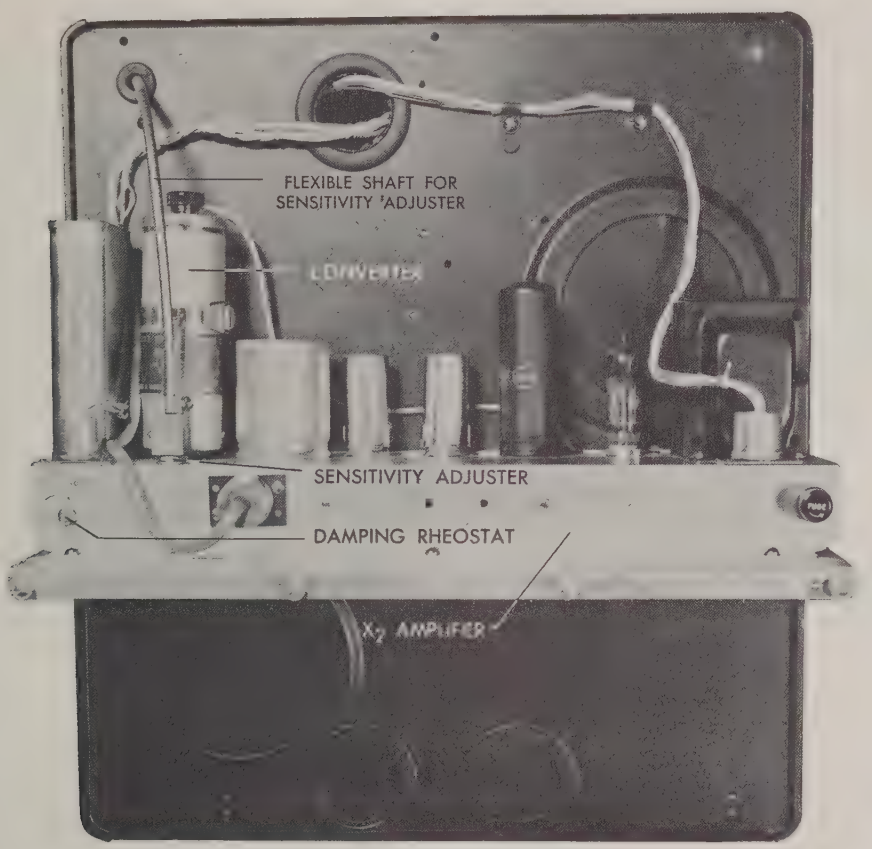


Fig. 6—Rear view of recorder case showing location of X_2 amplifier.

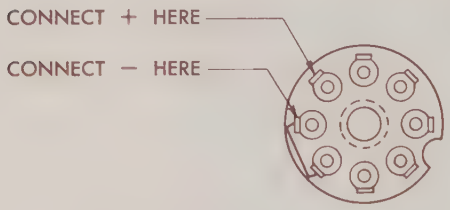
carriage support (see Fig. 5) so that the X_1 pointer is about 1/16" from the bottom of the scale. Then bend the front tab so that the clearance between the tabs and the guide shaft is a minimum. This prevents the pen from rotating around the shaft.

(c) Bend the X_1 pen bracket at Bend Point #1, Fig. 5, so that the pen point draws down the chart paper for a distance of about 1/16" to 3/32" when the chart assembly is raised. Bend the bracket down to increase this distance and bend it up to decrease the distance. While making this adjustment, hold the pen carriage assembly so that the adjustment made in Step (b) is not disturbed.

CAUTION: Never bend the pen assembly to make this or any other adjustment.

(d) Bend the X_2 pen carriage at Bend Point #3 until the bracket is in a vertical position as shown in Fig. 5. While bending the carriage, hold the pointer-carriage drive punching securely.

(e) Bend the X_2 pen bracket at Bend Point #2 until the two pen points are the proper distance apart (see first paragraph in this section) and until they touch the chart paper at the



When checking calibration, disconnect thermocouple from recorder's terminal board. After completing check, reconnect thermocouple.

Fig. 7—Connections of emf terminals of reference potentiometer to reference junction compensator.

same time when the chart assembly is raised. For pens which travel the full scale width for each recorded function, the pen points should be about 1/32" apart with the chart assembly in its lowered position.

(f) If the X_2 pen is too close to the X_1 pen, rebend the X_2 pen carriage slightly at Bend Point #3 by pulling the bottom of the carriage to the left as viewed in Fig. 5. This will increase the distance between the pen points and raise the X_2 pen point. Then repeat the adjustment described in Step (e).

(g) If the X_2 pen is too far away from the X_1 pen, rebend the X_2 pen carriage slightly at Bend Point #3 by pushing the bottom of the carriage to the right as viewed in Fig. 5. This will decrease the distance between the pen points and lower the X_2 pen point. Then repeat the adjustment described in Step (e).

(3) Alignment of Pens With Chart

Rotate split gear G, Fig. 3, located behind either slidewire, until this gear is against the low-end stop. If the pen is arranged for 100% chart travel, the pen point should register on the first line of the chart. If it is not arranged for 100% travel, then the pen point should register on its proper "zero" line.

If an adjustment is necessary, remove the terminal block for the X_2 balancing motor. Then loosen the screw which secures the pen carriage to the drive cord. Hold the split gear G against the low-end stop and move the pen carriage until the pen point is on the proper line of the chart. Tighten the screw to hold the pen carriage on the drive cord in this position. Replace the motor terminal block.

With both split gears held against their low-end stops, both pointers should register opposite the proper lines on the scale. To satisfy

Fig. 8—Lubrication of reduction gear section of chart drive motor.

this condition, it may be necessary to adjust the horizontal positions of the pointers and scale. To adjust the horizontal position of the X_1 pointer, loosen the two screws which secure it to the X_1 pen carriage. To adjust the horizontal position of the X_2 pointer, loosen either one of the two pairs of screws at the X_2 pen carriage. If necessary, the horizontal position of the scale may also be adjusted by loosening the two screws which secure it in place. (See Fig. 5.)

The X_1 pointer must not rub against any part of the scale. If necessary, bend the pointer until it clears the scale by about 1/16".

12D. Replacement of Dry Cells

A Wheatstone bridge measuring circuit may employ either an a-c or d-c bridge. When a d-c bridge is used, a dry cell will be used. In this instance, a small d-c voltmeter is mounted above the indicating scale. When the dry cell is fresh, the meter pointer will be well over to the right (on the white section of the scale). When the pointer moves to the red section of the scale, replace the dry cell with a fresh one.

12E. Amplifier

It is recommended that a spare set of electron tubes be stocked to aid in servicing either of the two amplifiers. When insensitivity is noticed, even with the sensitivity rheostat in its highest position, check the tubes. It is suggested that any weak tubes be replaced with new ones. These tubes may be purchased locally; however, it is preferable to order tubes, which have had a more complete quality check, from the Leeds & Northrup Company.

If the recorder should perform improperly and new tubes do not remedy the trouble, remove the pertinent amplifier and replace it with a new one.

13. MISCELLANEOUS SERVICING

13A. Installation of Pen Carriage Drive Cords

Before attempting to install the drive cords, remove the two measuring slidewires and rotate the split gears (while holding the main pulley) until the tension reel on each main pulley is accessible through the hole in each split gear.

Rotate main pulley #1 counterclockwise (as viewed in Fig. 9) until the mechanical stop is reached. Knot the cord as near the end as possible. Then slip the cord down into the slot in the main pulley and pull the cord through the slot until the knot registers in the recess on the back of the pulley. Pass the cord over the main pulley to the set of small pulleys at the center. Continue around the other pulleys with cord #1 as indicated in Fig. 9 and back to main pulley #1 again. Wind the cord around main pulley #1 counterclockwise to the tension reel. Loosen the two screws which clamp the reel and insert the cord in the reel. Tighten the two clamping screws slightly to hold the reel. Then wind the cord onto the reel until it is taut. Then tighten the clamping screws securely to be sure that the reel does not slip.

Rotate main pulley #2 counterclockwise (as viewed in Fig. 9) until the mechanical stop is reached. Thread the cord down through the hole in the pulley and knot the end which has been threaded through the hole. Then draw the cord back through the hole again until the knot registers against the bottom of the hole. Pass the cord over the main pulley to the front pulley

of the lower set of pulleys on the side of the frame. Continue around the other pulleys as indicated in Fig. 9 and back to main pulley #2. Wind the cord around the main pulley counter-clockwise to the tension reel, passing behind the other end of the cord. Wind the cord on the tension reel in the same manner as cord #1 was wound.

Place the cords under the clamping screws on their respective pen carriages and adjust the pen carriage as directed in Section 12C.

Remount the measuring slidewires which were removed at the beginning of the procedure.

13B. Replacement of Slidewires

Since both measuring slidewires are mounted in the same manner, the following instructions apply to either slidewire.

To remove a measuring slidewire from its shaft, proceed as follows:

(1) Remove the slidewire assembly by removing the screw (67 in Fig. 2) and washer from the end of the shaft. Then slide the entire slidewire assembly off the shaft. Remove the electrostatic shield and insulator from the rear of the assembly. Note the leadwire color coding and the location of the connecting pins on the rear of the slidewire to which they are connected. Then unsolder the leads from the connecting pins.

(2) Rotate the cover on the slidewire a slight amount in the counter-clockwise direction and remove it from the slidewire.

(3) Back out screw 180, Fig. 2, to release pressure on arm 182.

(4) Remove the two screws 181 and remove arm 182 complete with contacts 183.

(5) If the present contacts show signs of wear, remove them and mount new contacts as indicated in Section 12C.

(6) Remove the two screws 185 and remove the slidewire disk.

(7) Locate the replacement slidewire in the housing and secure it in position with the two screws 185.

(8) Fit arm 182 in place, with contacts 183 on the slidewire, and replace and tighten screws 181 just enough to hold the arm in place.

(9) Adjust screw 180 to obtain the required contact pressure. For high speed recorders using four contacts this pressure must be one ounce; for other recorders the pressure must be about two to three ounces. Tighten screws 181 to hold this adjustment.

(10) When four contacts are being used the contacts must be in alignment. The slotted contact assembly may be shifted on the support arm to attain this condition. (It may be necessary to rotate the support arm to the cutout in the housing to gain access to the contact assembly screws.) Tighten screws 184 after making any adjustment.

(11) Solder the leads to the connecting pins on the rear of the slidewire, being sure to connect the color coded leads to the pins corresponding to the original connections as noted previously. Replace the electrostatic shield and fibre insulator.

(12) Remount the slidewire assembly on the shaft and secure it in place with screw and washer 67.

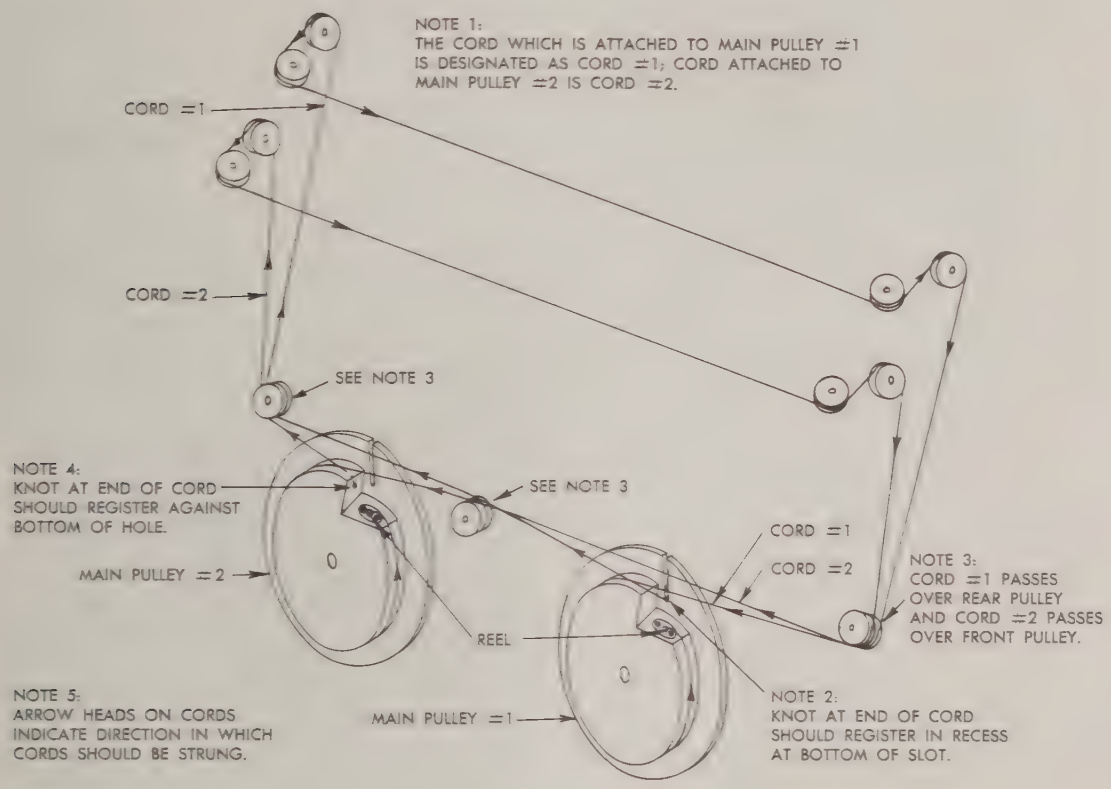

NOTE 1:
THE CORD WHICH IS ATTACHED TO MAIN PULLEY #1 IS DESIGNATED AS CORD #1; CORD ATTACHED TO MAIN PULLEY #2 IS CORD #2.
CORD #1
CORD #2
SEE NOTE 3
NOTE 4:
KNOT AT END OF CORD SHOULD REGISTER AGAINST BOTTOM OF HOLE.
SEE NOTE 3
MAIN PULLEY #2
CORD #1
CORD #2
NOTE 3:
CORD #1 PASSES OVER REAR PULLEY AND CORD #2 PASSES OVER FRONT PULLEY.
REEL
NOTE 5:
ARROW HEADS ON CORDS INDICATE DIRECTION IN WHICH CORDS SHOULD BE STRUNG.
MAIN PULLEY #1
NOTE 2:
KNOT AT END OF CORD SHOULD REGISTER IN RECESS AT BOTTOM OF SLOT.

Fig. 9—Drive cord arrangement.

(13) Check the recorder calibration and make corrective adjustments, if necessary, as explained in Section 11.

(14) Replace the cover on the slidewire.

13C. Installation of Slidewire Contacts

To install new contacts on a measuring slidewire, proceed as follows:

(1) Rotate the cover on the measuring slidewire a slight amount in a counterclockwise direction and remove it from the slidewire.

(2) Back out screw 180, Fig. 2, to release the pressure on arm 182.

(3) Remove the two screws 181 and remove arm 182 complete with contacts 183.

(4) Remove the four screws 184 and remove the small block(s) and the attached contacts.

(5) Place the new contacts and block(s) in position on arm 182 and fasten them in place with the four screws. Note that for high speed recorders using four contacts the slotted block assembly is placed next to the right angle bend in arm 182.

(6) Fit arm 182 in place with contacts 183 on the slidewire, and replace

and tighten screws 181 just enough to hold the arm in place.

(7) Adjust screw 180 to obtain the required contact pressure. For high speed recorders using four contacts this pressure must be one ounce; for other recorders the pressure must be about two to three ounces. Tighten screw 181 to hold this adjustment.

(8) When four contacts are being used the contacts must be in alignment. The slotted contact assembly may be shifted on the support arm to attain this condition. (It may be necessary to rotate the support arm to the cutout in the housing to gain access to the contact assembly screws.) Tighten screws 184 after making any adjustment.

(9) Check the recorder calibration and make corrective adjustments, if necessary, as explained in Section 11.

(10) Replace the cover on the slidewire.

PART IV

TECHNICAL INFORMATION

14. SUMMARY

The 69955 Speedomax G X_1-X_2 Recorder employs an automatic null-balance measuring system for each function in which balance is accomplished through the use of an electronic amplifier. The essential parts of such a system are: (1) the null-balance measuring circuit, (2) the null-detector amplifier, (3) the balancing motor and linkage, and (4) the display system (that is, recording and indicating devices).

In the measurement of an emf—for example, the emf obtained from a thermocouple—the measuring circuit consists of an adjustable calibrated emf which is connected in opposition to the emf being measured. If these two emfs are not equal, an "error" or unbalance current flows and is detected by the input circuit of the amplifier. The calibrated emf is obtained from a measuring slidewire whose movable contact is positioned by the balancing motor until the calibrated emf is equal to the emf being measured.

Any error signal (that is, any difference between the emf being measured and calibrated emf) is converted into a-c by a synchronously vibrating contactor and then amplified by the amplifier. After amplification, the error signal is applied to the control winding of the reversible balancing motor which then works through the mechanical linkage to adjust the calibrated emf. The current in the driving coil of the synchronous converter is so phased that the amplified signal on the control winding is substantially in quadrature with the voltage applied to the line winding of the balancing motor. Thus maximum motor torque is obtained for any unbalance in the measuring circuit.

The system is sensitive to the direction of error current so that the motor always adjusts the calibrated emf in the proper direction to reduce the magnitude of the error current. The motor continues to drive until the error current is so small that the amplified signal will no longer produce motor rotation. Amplification is such that this occurs when the error current is substantially zero and the calibrated emf differs by only a negligible amount from the emf being measured. A null or balance condition then exists.

While adjusting the calibrated emf, the motor also drives the display system. Therefore, the pointer and

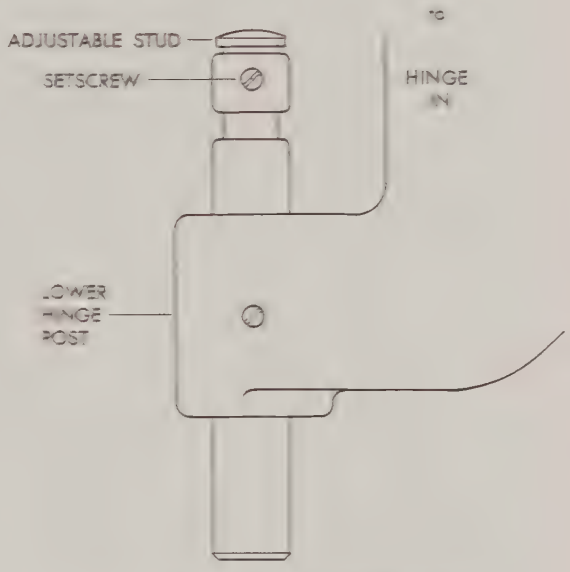


Fig. 10—Lower hinge on main frame assembly.

pen position directly indicate the calibrated emf and hence the emf being measured. The indicator scale is marked in terms of the variable producing the measured emf.

Although the foregoing explanation applies particularly to emf measurement, the basic method is equally applicable to measurement of resistance. In both instances, a precise known quantity is continuously and automatically adjusted to be equal to the quantity being measured.

15. MEASURING CIRCUITS

15A. Potentiometer Circuit

A thermocouple potentiometer circuit is illustrated in Fig. 11. This circuit is arranged with two branches of equal resistance to which constant current is applied by a regulated voltage power supply unit. The magnitude of this current can be controlled by a screw adjustment provided on the power supply unit. In Speedomax G potentiometer type instruments, it is customary to provide a total constant current of 10 ma which divides equally between the two branches of the circuit. Thus the voltage across the two branches is equal.

During normal measurement, the balancing motor associated with this potentiometer circuit drives the slidewire contact until the emf being measured E_X is equal to the calibrated emf E_S (that is, the potential difference between the slidewire contact and the junction of resistors D and C). By proper selection of the circuit resistors (G, S, K, B, D, and C), the calibrated emf E_S can be made to vary through the desired measuring range. This range may start at zero, be suppressed, or be elevated as the contact moves over the slidewire.

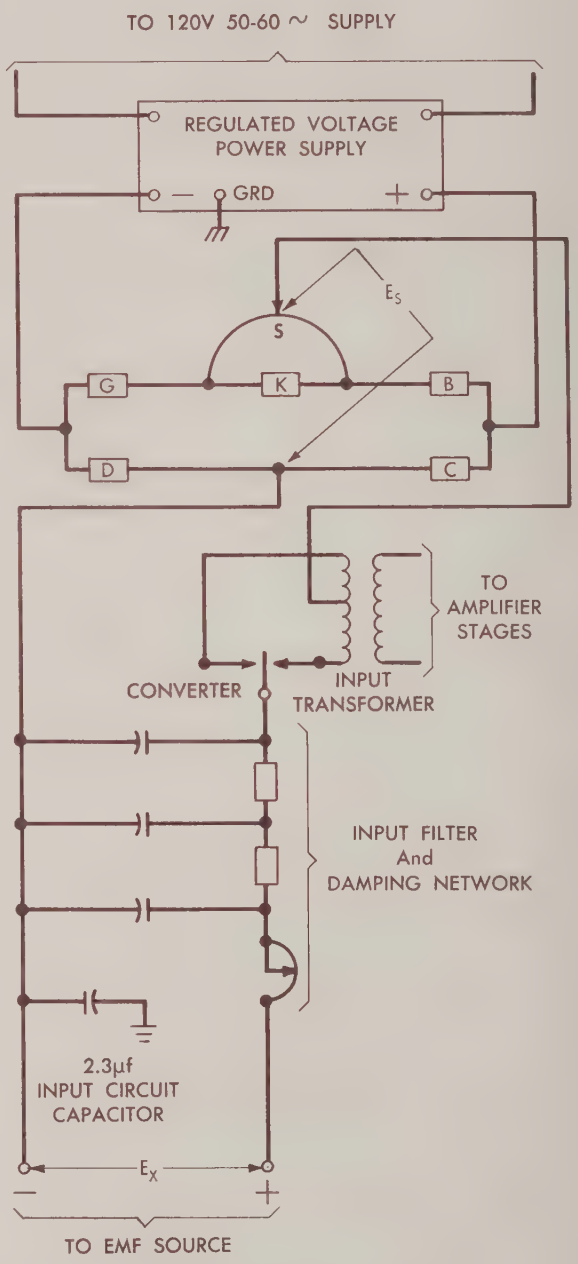


Fig. 11—Potentiometer circuit.

A special temperature-sensitive resistor D provides the necessary reference junction compensation. It is composed of copper and nickel in such proportions that, over a limited

range, its temperature characteristic matches that of the thermocouple being used. With a constant current of 5 ma flowing through D, any change in its temperature produces a corresponding change in the potential drop across it and thereby moves the balance position of the slidewire contact up or down scale. Since the D resistor is in close proximity to the thermocouple reference junction, it is affected by the same temperature variations that affect the reference junction. Thus it causes the balance point to shift automatically by the correct amount to compensate for any change in the reference junction temperature.

15B. Wheatstone Bridge Circuit

A Wheatstone bridge circuit for measuring resistance is shown in Fig. 12. As shown, two slidewires, S_1 and S_2 are employed. These wires are mounted on a common molding and their contacts move in unison. The resistance relationships in the circuit are chosen as shown in the figure. Thus, for any contact setting, the resistance between points 1 and 2 is always equal to that between 2 and 3. That is, the ratio arms are always equal, so that when the bridge is balanced, the resistance being measured R_X is equal to the resistance of the arm containing resistor R. The measuring range of the bridge circuit is, therefore, from R to R + S_1. Any unbalance causes an error current to flow through the amplifier input circuit. After amplification this signal is applied to the balancing motor which then drives the slidewire contacts in the proper direction to restore balance.

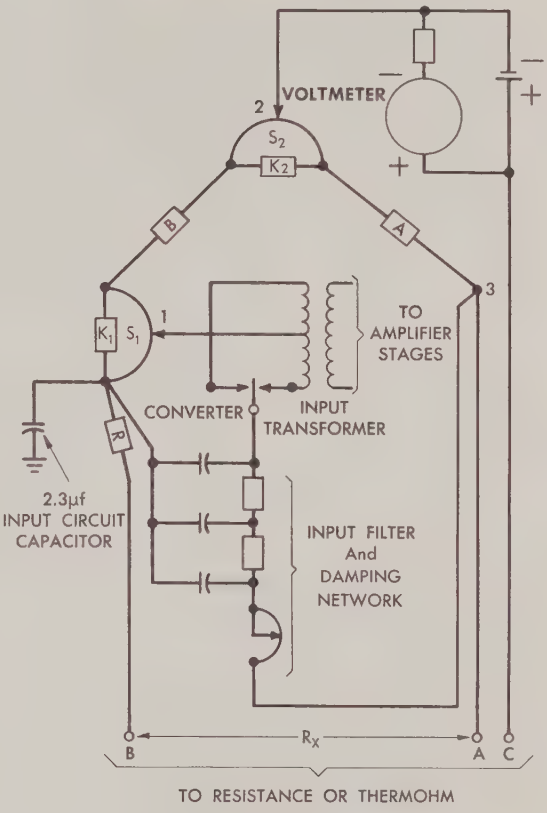


Fig. 12—Wheatstone bridge circuit.

16. FILTERING

The emf or resistance being measured may be generated or located at a considerable distance from the recorder. Under this condition, a-c voltages are likely to be picked up in the long connecting leads. In particular, electrostatic and electromagnetic coupling of the leads with power lines and equipment may cause a-c of line frequency—usually 60 cycles—to be introduced into the measuring circuit. Without filtering, this interference signal would be chopped by the converter and would enter the amplifier together with the d-c unbalance signal. Although the amplified interference signal may not drive the balancing motor, it does tend to overload the amplifier, thereby decreasing the response to the legitimate signal and causing sluggish performance. If a-c interference were great, complete amplifier paralysis could result.

16A. Input Filter

To minimize the effect of a-c interference developed across the input leads (transverse interference) the measuring circuit employs a three section R-C filter located on the amplifier chassis. This filter is proportioned to produce more than 99% attenuation of 60 cycle emf superimposed on the legitimate signal.

For the most effective filtering action, the input filter would be connected directly across the amplifier input. It would then attenuate the a-c components of all signals entering the amplifier. As will be described in Section 17, the filter is also arranged to provide damping; therefore it cannot be connected directly across the input. Note that in the potentiometer circuit, the filter will attenuate a-c pickup in the primary element and its leads, but does not have the same effect on a-c signals induced in other measuring circuit elements. Similarly, in the Wheatstone bridge circuit, the filter will attenuate a-c which is picked up in the lower arms of the bridge (including the resistance to be measured R_X and its leads), but will be only partially effective in eliminating a-c signals induced in other circuit elements. Therefore, precautions are taken to prevent a-c from being induced in the measuring circuit wiring and the components inside the recorder case. This is accomplished chiefly by the physical arrangement of the measuring circuit and its components.

16B. Input Circuit Capacitor

A 2.3 μf capacitor is usually incorporated in the measuring circuit. Connected as shown in Figs. 11 and 12, this capacitor provides a low impedance path for interference developed between the input leads and ground (longitudinal interference). It thus minimizes the amount of such interference entering the amplifier.

17. DAMPING

Maximum balancing motor torque is developed from an amplifier input equivalent to a measuring circuit unbalance of only 40 microvolts or 0.4% of a 10 millivolt range span. This steep torque gradient is desirable since it provides high measuring sensitivity (that is, small dead band). However, in the absence of any other provision, the recorder would constantly overshoot the balance point, because any large unbalance would bring the motor up to full speed with no torque reduction until the system approached within 0.4% of balance. To prevent such overshoot and consequent "hunting" (oscillation) of the system, damping is provided.

The resistive and capacitive elements of the input filter provide the necessary damping action. A simplified rearrangement of the input filter of a potentiometer circuit, using only a single R-C section for clarity, is shown in Fig. 13.

At balance the calibrated emf E_S, the emf being measured E_X, and the voltage across the C capacitor E_C are all equal. Now assume that E_X increases, its polarity remaining as shown. Owing to the unbalance between E_X and E_S, an error current flows in the amplifier input circuit as shown, causing the slidewire contact to move upscale to restore balance. As the contact moves, E_S increases causing a changing (damping) current to flow through capacitor C and the amplifier input circuit. The damping current is proportional to the rate of change of E_S and therefore to the slidewire contact velocity.

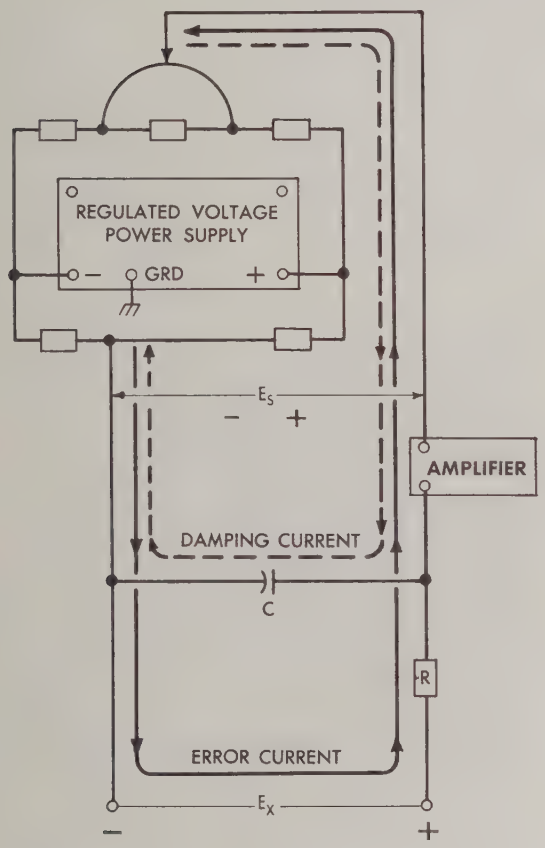


Fig. 13—Damping and error currents in potentiometer circuit.

Now there are two currents flowing in the amplifier input circuit; one (error current) proportional to the unbalance and causing upscale motion; the other (damping current) proportional to the contact velocity and tending to cause downscale motion. As the balance point is approached, the error current reduces to zero but the damping current persists as long as the instrument attempts to overrun the balance point. Near the balance point the damping current predominates, applying reverse torque to the balancing motor and thereby braking the motion smoothly without overshoot.

A damping control (the adjustable resistor in the first R-C section of the input filter—see Figs. 11 and 12) is mounted on the amplifier chassis. This control is provided for adjusting the damping of the measuring system, as required.

18. CONVERSION OF ERROR SIGNAL

Conversion of the d-c error signal to a-c is accomplished by the synchronous converter ("chopper") and the input transformer which are mounted on the amplifier. The converter connects the d-c signal alternately to the two halves of the input transformer's primary winding. This causes the direct current to flow first through one half of the winding and then through the other half in the opposite direction. Thus, a 60 cycle alternating voltage—approximately a square wave—is induced in the transformer secondary winding and is applied to the grid of the first amplifier tube.

The magnitude of the induced secondary voltage is proportional to the magnitude of the d-c measuring circuit unbalance voltage. Moreover, the phase of this voltage depends upon the direction of the d-c unbalance signal. For, if the polarity of the unbalance signal is reversed, then the transformer primary current flows in the opposite direction during each half cycle, thereby reversing the instantaneous polarity of the secondary voltage (that is, shifting its phase by 180 degrees).

18A. Converter

The converter is essentially a single-pole double-throw switch which is operated by the motion of a metal reed. The drive coil at the top of the unit is supplied with 60 cycle

current from the amplifier's power transformer and thus produces a 60 cycle alternating magnetic field. Owing to the small permanent magnet at its upper end, the reed vibrates in response to the magnetic field, thereby operating the converter contacts in synchronism with the 60 cycle line.

18B. Input Transformer

This is a 1:10 step-up transformer. Since this transformer is in the low-level circuit, special precautions have been taken in its design. Thus the transformer coils are of "humbucking" construction. That is, each coil section is wound in such a way that voltages induced by external magnetic fields are canceled out. In addition, the coil is enclosed within four concentric mumetal shells, for magnetic shielding, while the outer case of the transformer provides electrostatic shielding.

19. VOLTAGE AMPLIFICATION

As described previously, the error signal developed in the measuring circuit must be sufficiently amplified to operate the recorder's balancing motor. Voltage amplification is provided by one and a half 12AX7 twin-triode tubes and one 6L6 power tube—a total of four consecutive voltage stages employing conventional resistance-capacitance coupling. A 6X4 rectifier tube provides filtered d-c plate supply for the other tubes. A gain control between the first and second stages of the amplification provides a means of adjusting the sensitivity of the balancing system. The plate current of the 6L6 tube is applied directly to the control winding of the balancing motor. However, only the a-c component of the plate current causes rotation of the balancing motor.

20. BALANCING MOTOR OPERATION

The balancing motor is a specially-designed, two-phase, induction motor which has separate line and control windings. It is geard to the slidewire contact shaft through a pair of spur gears spring loaded in opposite directions to prevent backlash or "play".

To cause rotation of the balancing motor, the amplifier output (output of the 6L6 tube), which is applied to the control winding, must be so phased that it is 90 electrical degrees out of phase with the voltage applied to the line winding, which is connected directly to the line. This is accomplished by the design of the amplifier: namely, in that the phasing capacitor in combination with the impedance of the converter's driving coil shifts the voltage applied to the converter coil 117 degrees; in that the mechanical lag in the converter is 51 degrees; and in that the phase advance through the amplifier is 24 degrees. Thus the phase difference between the voltages applied to the control and line windings is equal to 117 minus 51 plus 24 degrees or 90 degrees.

If the control winding voltage leads the line voltage by 90 degrees, the motor turns in one direction; if it lags the line winding voltage by 90 degrees, the motor turns in the opposite direction. Thus the direction of motor rotation reverses whenever the phase of the control winding voltage reverses 180 degrees.

As the motor turns, it adjusts the slidewire contact until the calibrated emf is equal to the emf being measured. When this null-balance condition is obtained, the error signal developed in the measuring circuit is substantially zero and the voltage

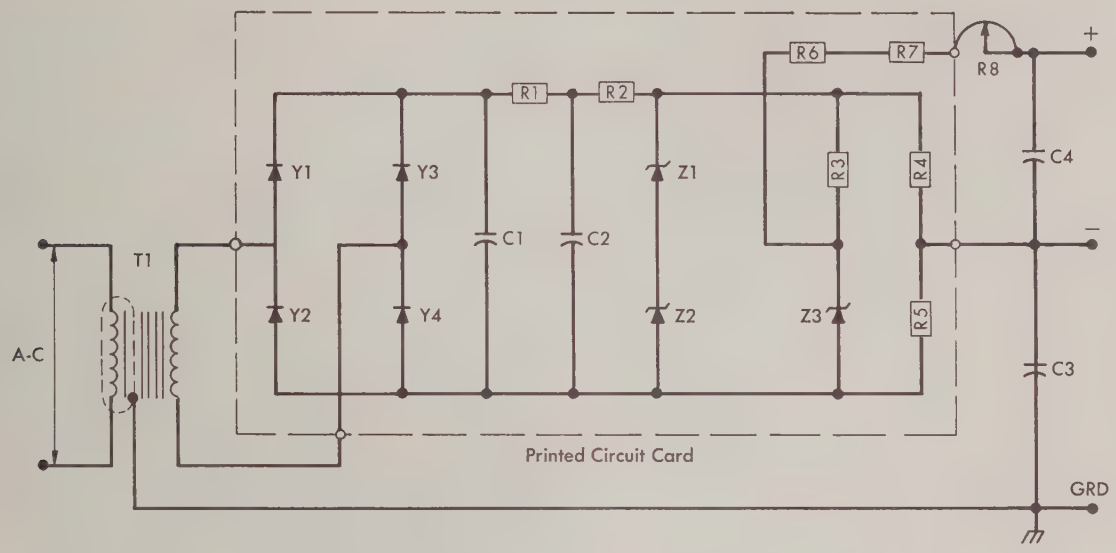


Fig. 14—Circuit diagram of regulated voltage power supply unit.

across the control winding is no longer capable of developing enough torque to turn the motor.

21. REGULATED VOLTAGE POWER SUPPLY UNIT

This power supply unit is primarily used in potentiometer (thermocouple, emf, etc.) circuits. However, it can be used in other circuits such as d-c Wheatstone bridge circuits, if ordered as an optional feature.

The unit converts the normal a-c line voltage into a highly stable d-c voltage output. The magnitude of this output is such that the unit can be adjusted to supply a 10 ma output current to the measuring circuit. Since the unit's output voltage is highly stable* and since the resistance of the measuring circuit is essentially constant, the 10 ma current applied to the measuring circuit is therefore constant.

A circuit diagram of the power supply unit is shown in Fig. 14. As indicated by this diagram, the unit operates in the following manner.

The normal a-c line voltage is reduced in magnitude by power transformer T1 whose primary and secondary windings are physically isolated to minimize adverse capacitive effects. The transformer's a-c output voltage is then changed to d-c voltage by a full-wave rectifier bridge comprising silicon diodes Y1, Y2, Y3, and Y4. The d-c output of this bridge is filtered by a filter network to suppress the a-c ripple and is then applied across a pair of Zener diodes (Z1 and Z2) which are connected in series. These diodes provide the first stage of voltage regulation (pre-regulation) for the unit in that they maintain the filtered output of the rectifier bridge at 13 volts d-c within ±5%. The unit's second and final stage of voltage

* Ambient temperature variations between 16 and 75 C and a-c line voltage variations between 107 and 127 volts and 48 and 64 cycles will not affect the precision of the unit's d-c voltage output.

regulation is provided by a bridge circuit consisting of resistors R3, R4, R5, and Zener diode Z3. The effect of the Zener diode on the current flowing in this bridge changes the relationship between the voltage changes at the R4-R5 and R3-Z3 junctions produced by variations in the applied voltage. That is, voltage changes at these two junctions with respect to a third point will be equal volt for volt; whereas, without the Zener diode the percentage changes would be equal. Thus the bridge operates to maintain a constant voltage difference between the two junctions to within ±0.07% at temperatures up to 65 C.

The output of the final stage is compensated for temperature effects on the characteristics of Zener diode Z3 by the use of a series-connected nickel resistor R6, which is wound around Zener diode Z3. This resistor-diode combination is encapsulated so that the combination is always at the same temperature. Since resistor R6 is connected in series with the bridge output, any temperature change at diode Z3 will be automatically compensated for by resistor R6. In addition to resistor R6, precision resistor R7 and rheostat R8 are connected in series with the bridge output. These components determine the d-c output voltage of the power supply unit. The magnitude of this voltage can be adjusted to supply 10 ma to the potentiometer circuit by an external adjusting screw* on the power supply unit which is connected to rheostat R8. Capacitors C3 and C4 are incorporated into the power supply unit's circuit to help maintain output stability and to reduce output noise.

* To gain access to the adjusting screw, it will be necessary to remove the chrome plug button from the terminal side of the unit. Fig. 3 shows the locations of the power supply units.

APPENDIX I

RECOMMENDED SPARE PARTS

DESCRIPTION	L&N PART NO.	QUANTITY PER RECORDER
Cartridge Fuse, 3 ampere	Std. 3246-113	2
Spring Washer for paper drive	R-10503-Q	1
Thrust Washer for paper drive	R-503-Y	1
Spring for reroll friction	R-503-W	1
Retainer Clip for worm	027096	2
Drive Cord for pens	R-25-D-2	2
Split Gear Assembly	R-10802-X	1
Spring Washer for split gear clutch assembly	R-510-Q-1	3
Ball Bearings for main shaft	R-815-L	2
Balancing Motor, 50/60 cycles	017138	*
Balancing Motor, 25 cycles	R-346-32-25-R	*
Bearings for balancing motors	008052	*
Chart Drive Motor, 25 cycles, 1 rpm	R-10346-5-25	*
Chart Drive Motor, 50 cycles, 1 rpm	R-10346-5-50	*
Chart Drive Motor, 60 cycles, 1 rpm	R-10346-5-60	*
Chart Drive Motor, 60 cycles, 4 rpm	17-2-0-15	*
Chart Drive Motor, 50 cycles, 60 rpm	R-346-22-50	*
Chart Drive Motor, 60 cycles, 60 rpm	R-346-22-60	*
Bearings for all chart motors	008052	*
Slidewire Contact Assembly (2 contact type)	R-30815-T	*
Slidewire Contact Assembly (4 contact type)	029495●	*
Converter for amplifier	△	1
Fuse for amplifier	△	1
First Voltage Tube for amplifier	△	1
Second Voltage Tube for amplifier	△	1
Power Tube for amplifier	△	1
Rectifier Tube for amplifier	△	1
X_1 Pen Assembly (Fig. 3)	054095	1
X_2 Pen Assembly (Fig. 3)	054091	1
Regulated Voltage Power Supply	099012	1

* Exact quantity to be determined by the user on the basis of the number of recorders in service.

● Replaces the previously used R-20815-AM (Single Unit Assembly) and also replaces the 29-5-0-8 (Adjustable Position) and 29-5-0-9 (Fixed Position) Contact Assemblies which were subsequently used in combination.

△ Use the part number marked on the amplifier chassis.

APPENDIX II

POTENTIOMETER MEASURING CIRCUIT EQUIPPED WITH MANUAL STANDARDIZING COMPONENTS

Any potentiometer measuring circuit can be equipped with manual standardization components in place of the regulated voltage power supply unit if such components are ordered specifically as an optional feature. The following sections cover information and instructions that are pertinent to such a circuit but that are not included in the main text of this instruction book.

A1. DESCRIPTION OF CIRCUIT

This type of measuring circuit is illustrated in Fig. A1. It is identical to the one described in Section 15A except the regulated voltage power supply unit is replaced with a dry cell, current rheostat, standard cell, and standardizing key.

A 69955 X_1-X_2 Recorder having such potentiometer circuits is equipped with an upper structure panel on which are mounted the recorder's line switch and the standardizing key and current rheostat for each function. The standard cell for such a recorder is mounted inside the hollow in the bottom of the main frame casting, between the shafts of the two measuring slidewires.

As shown in Fig. A1, the dry cell supplies a continuously flowing current of constant value (10 ma) to the potentiometer circuit. Since the circuit is arranged with two branches of equal resistance, this current divides equally between them. The magnitude of this current is controlled by the current rheostat which is connected in series with the dry cell. Since the dry cell is permanently connected in the potentiometer circuit, its emf will gradually decrease, thereby decreasing the value of the current supplied to the circuit.

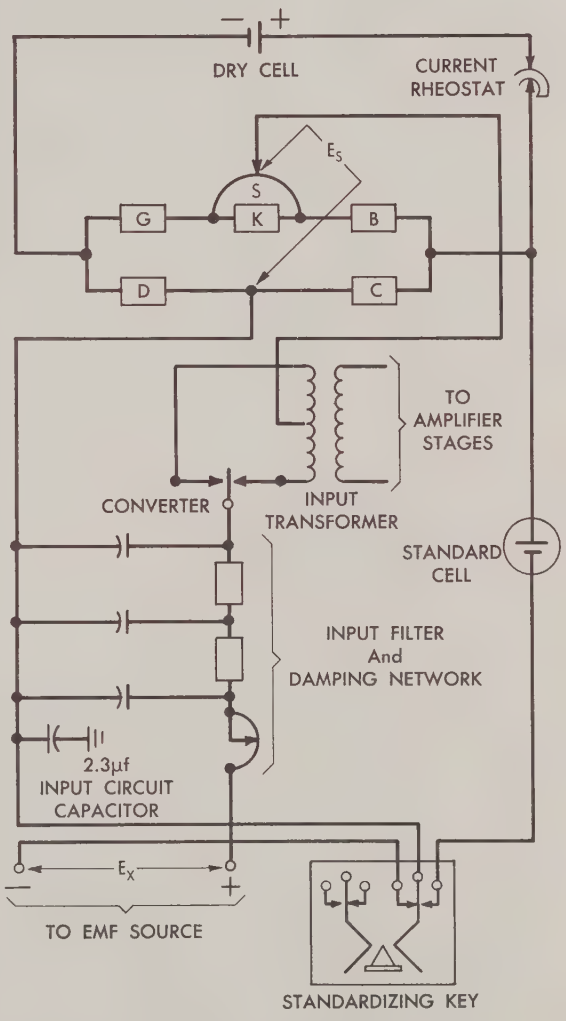


Fig. A1—Potentiometer circuit equipped with current standardization components.

To compensate for this decrease, a portion of the dry cell voltage (voltage across resistor C) is compared with the constant voltage of the standard cell. Then the current rheostat is adjusted until current of proper value is again flowing in the circuit. This is brought about by pressing the standardizing key. This key when pressed connects the amplifier's input circuit into a loop which also includes resistor C and the standard cell. If the voltage across resistor C is not equal to the voltage of the standard cell, the resultant voltage unbalance causes the circuit's balancing motor to rotate. This, in turn, causes the pen to drift indicating an unbalance. Now when the current rheostat is adjusted until no pen motion is observed, the two voltages become equal and opposite and current of the proper value (10 ma) flows through the potentiometer circuit.

A2. PRECAUTIONS FOR STANDARD CELL

The standard cell should never be exposed to temperatures below 32 F or above 140 F. To satisfy this requirement, the recorder, when operating continuously, should not be installed in locations where the ambient temperature is below 10 F or above 120 F. If it is necessary to use the recorder in such locations, remove the standard cell, mount it at a location where the temperature will be within the limits specified (32 F or 140 F), and then run twisted leads from the standard cell to the recorder. Both the standard cell and the leads should be shielded and the shielding grounded. Make sure the connections to the cell are made with the proper polarity. Also make certain the cell is mounted in the same relative position it was in, when it was mounted in the recorder. Do not short circuit the cell at any time and, when in use, do not invert the cell or stand it on its side.

A3. INSTALLATION OF DRY CELLS

The dry cells for the two potentiometer measuring circuits are supplied unmounted. Mount these cells in the holders provided for them inside the recorder case. Connect the leads to the cells in such a manner that the polarities marked on the leads match those of the cell terminals.

A4. ADJUSTMENT OF POTENTIOMETER CURRENT

Manual standardization of the potentiometer current is provided for each function's measuring circuit. The current rheostats and standardizing keys, which are used to bring about the standardization, are mounted above the recorder scale on an upper structure panel.

To adjust the current of either measuring circuit, press the pertinent standardizing key and adjust the corresponding rheostat until the pen which is operated by the measuring circuit stops moving, thereby indicating the circuit is balanced. If the pen should reach the mechanical stop at either end of its travel while the current is being adjusted, release the key to allow the pen to move away from the stop. Then depress the key again and continue the adjustment.

A5. REPLACEMENT OF DRY CELLS

When the arrow on either current rheostat reaches the index, replace the dry cell for the circuit associated with the rheostat. After the new dry cell has been installed, readjust the potentiometer current as directed in the previous section.

A6. CALIBRATION

To check the calibration of a potentiometer circuit equipped with manual standardization components, proceed as indicated in Section 11A. In addition, after allowing the recorder to warm up, adjust the circuit's potentiometer current as directed in Section A4.

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